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METHOD AND APPARATUS FOR MAKING KNITTED FABRICS

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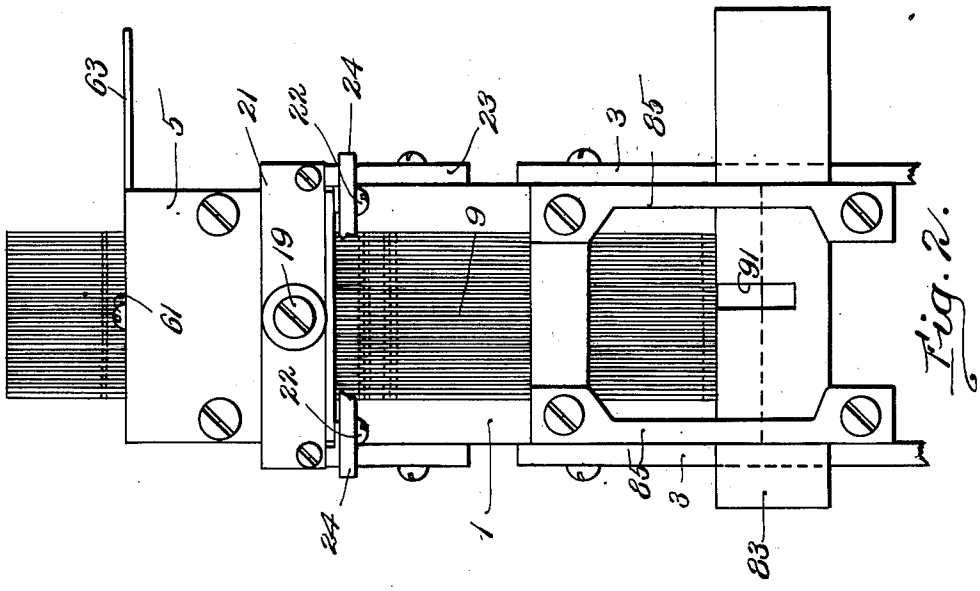

Fig. 2.

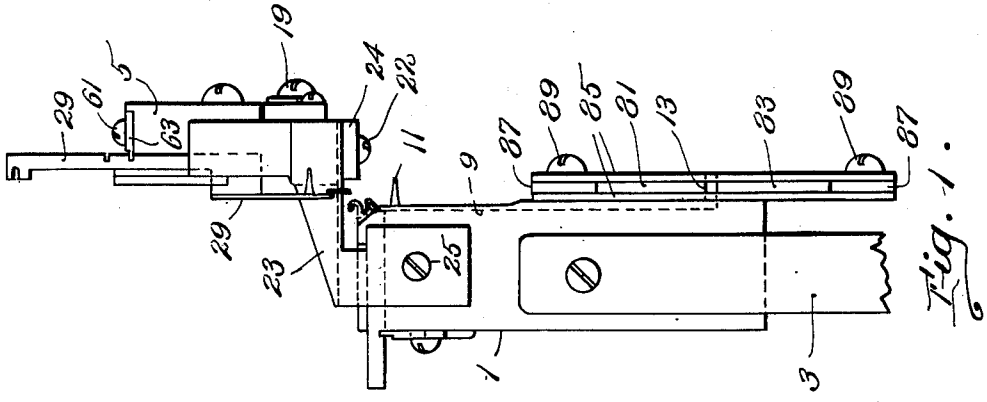

Fig. 1.

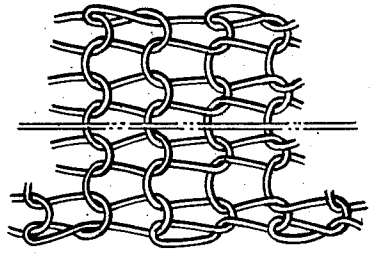

Fig. 3.

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METHOD AND APPARATUS FOR MAKING KNITTED FABRICS

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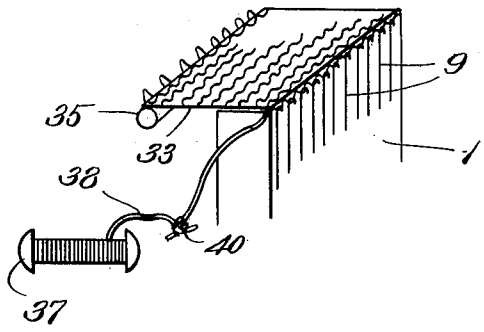
Fig. 4.



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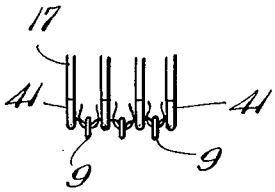

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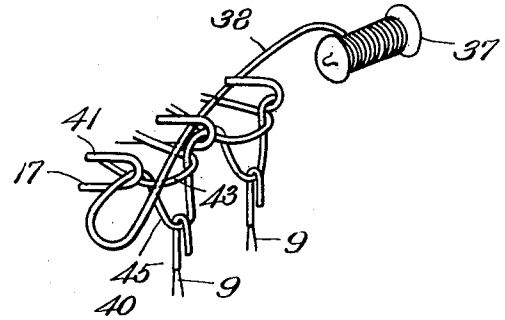

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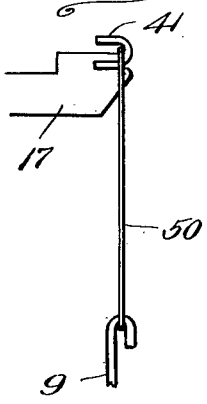

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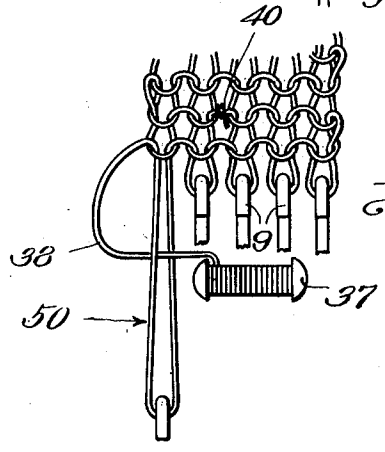

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Fig. 9.

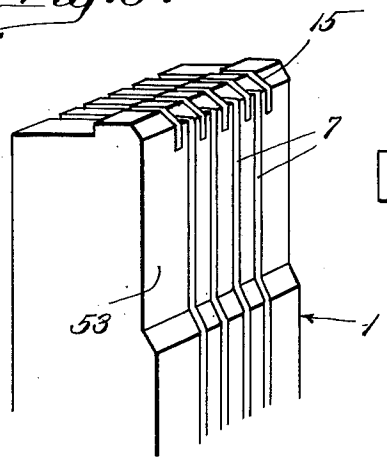

Fig. 10.

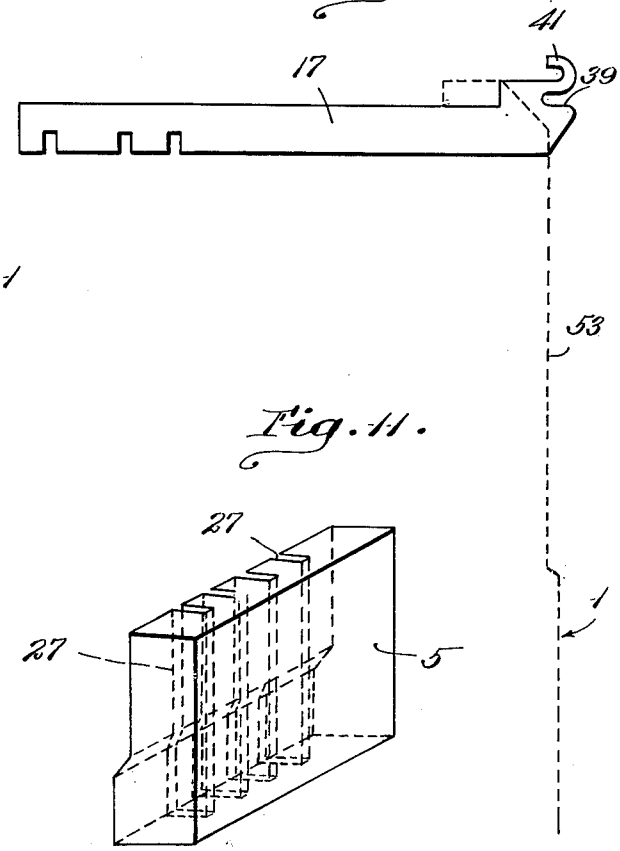

Fig. 14.

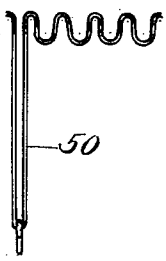

Fig. 11.

Fig. 12.

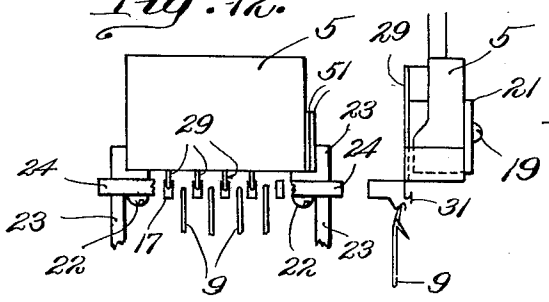

Fig. 13.

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Fig. 15.

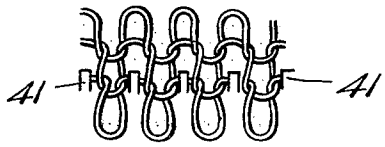


Fig. 17. Fig. 16.

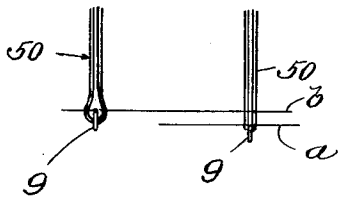
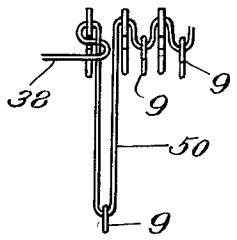


Fig. 21. Fig. 22.



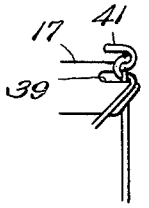
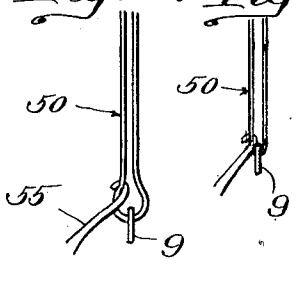


Fig. 18. Fig. 20.



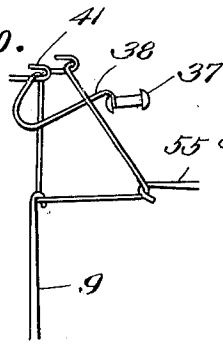


Fig. 19.

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Fig. 23.

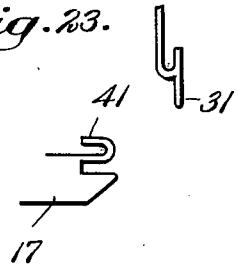


Fig. 24.

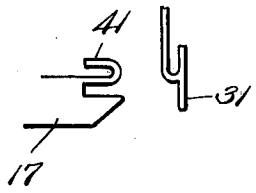
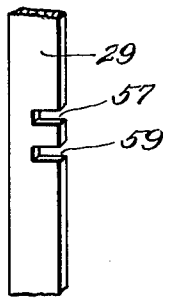


Fig. 25.



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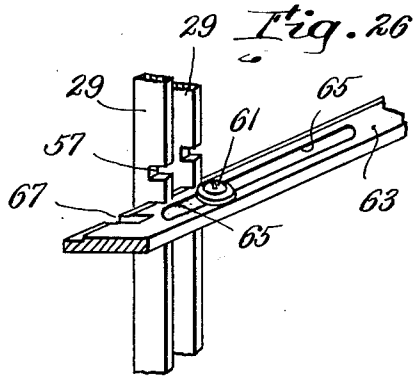


Fig. 27.

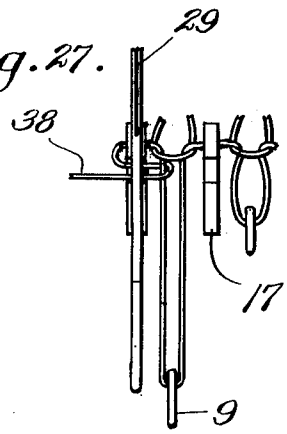
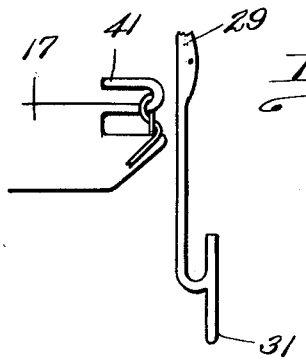


Fig. 28.



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METHOD AND APPARATUS FOR MAKING KNITTED FABRICS

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Fig. 29.

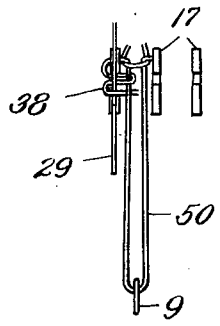


Fig. 30.

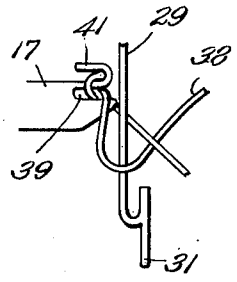


Fig. 31.

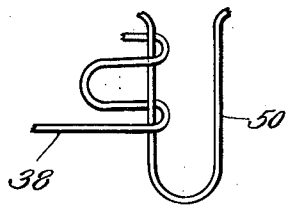
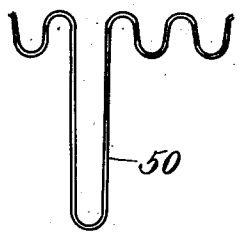


Fig. 32.



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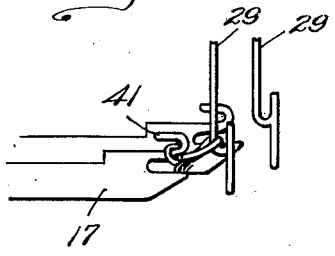


Fig. 36.

Fig. 34.

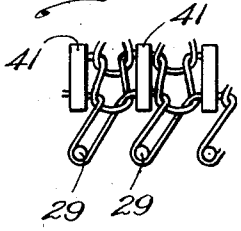
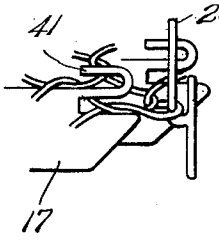
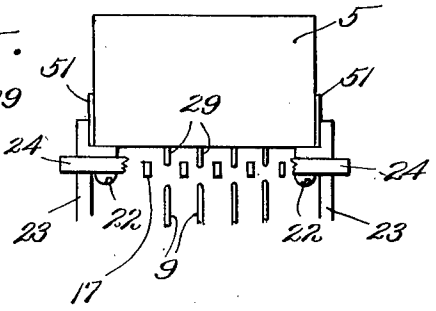


Fig. 35.





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METHOD AND APPARATUS FOR MAKING KNITTED FABRICS

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Fig. 37.

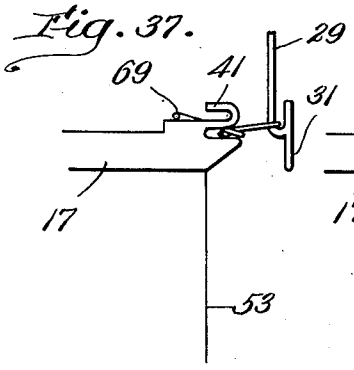


Fig. 38.

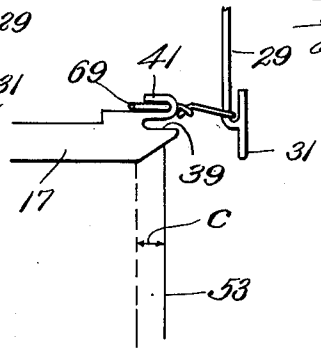
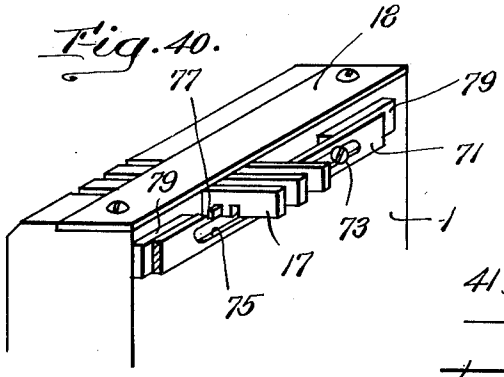


Fig. 40.



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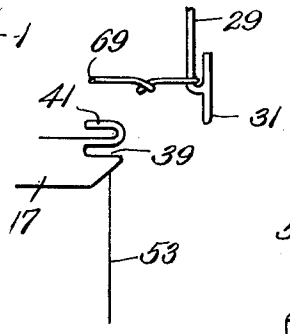


Fig. 42.

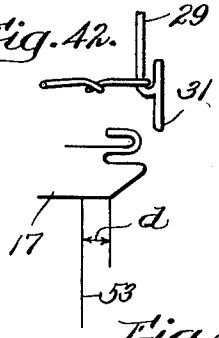


Fig. 43.

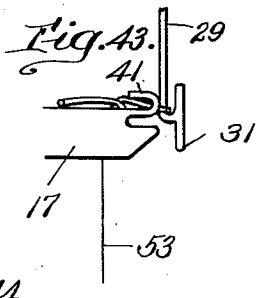


Fig. 44.

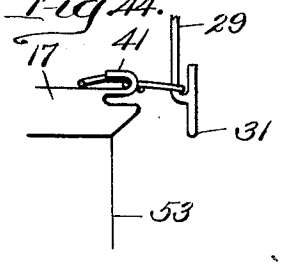
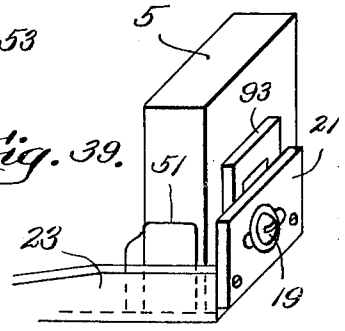


Fig. 39.



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METHOD AND APPARATUS FOR MAKING KNITTED FABRICS

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Fig. 49.

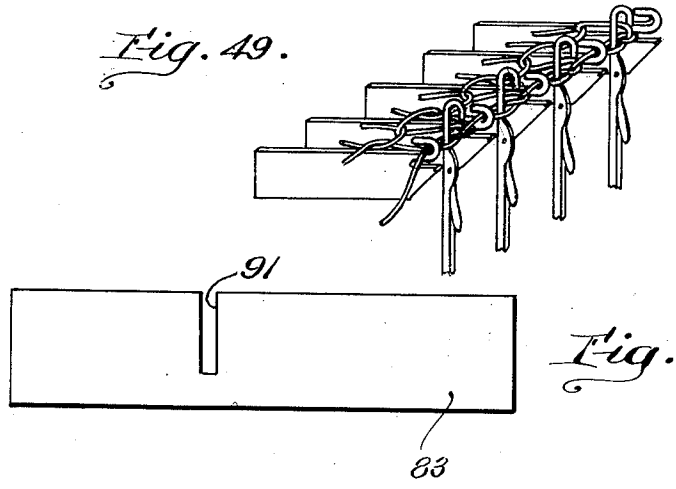


Fig. 45.

Fig. 46.

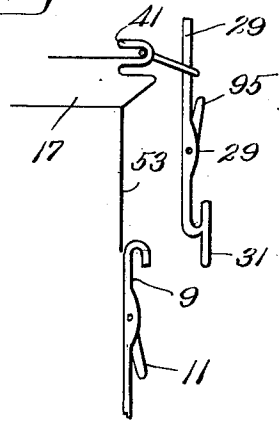


Fig. 47.

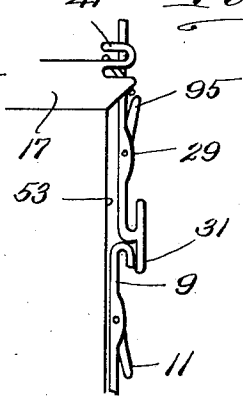
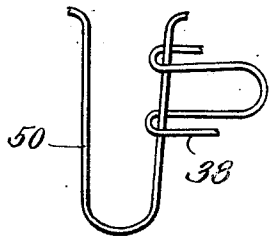


Fig. 48.



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Patented Apr. 1, 1952

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UNITED STATES PATENT OFFICE

2,590,914

METHOD AND APPARATUS FOR MAKING KNITTED FABRICS

Harry D. Adams, Allston, Mass., assignor to Joseph D. Ramsey, Watertown, Mass., in trust

Application September 29, 1945, Serial No. 619,357

18 Claims. (Cl. 66—1)

1

This invention relates to knitting, and more especially to the knitting of fine or sheer grades of natural silk and synthetic fiber fabrics for use in stockings primarily for women's wear.

A leading object of the invention is to provide a stocking fabric which can be produced economically and under commercial conditions by a knitting process, and which will be the equivalent in fineness, weight of yarns, character or pattern of stitch, and inherent elasticity or capacity for recovery of shape, and hence identical in appearance and use, to the conventional plain knit women's stockings, but which differs fundamentally therefrom through the use of a stitch which cannot run when a thread is broken. As is well known, the basic weakness in the standard plain knit stocking which comprises by far the preponderant style of hosiery worn by women is their proneness to develop runs which either terminate the useful life of the stockings or seriously impair their appearance. This results from the inherent character of the stitch used in plain knitting, in which each stitch comprises a simple loop which is pulled through and thus suspended from another loop and held from escape from the suspending loop only by the pull of a third loop in the wale in question, this relationship being repeated throughout the wale. Upon fracture of the yarn at any point in a wale, a frequent occurrence because of the fine counts of yarn compelled to be used to satisfy the demand for sheerness of the resulting stocking, the slightest strain on the fabric withdraws the broken ends from the adjacent loops, whereupon each loop or bend of the wale or wales involved in the break is in turn released so that it is pulled straight by the slightest widthwise strain on the fabric, and in so doing simply backs out of the adjacent loop in the wale, thus releasing such adjacent loop to do likewise, with nothing to prevent it continuing throughout the entire length of the wale in both directions throughout the entire length of the plain knit portions of the fabric.

Many ways of overcoming this basic weakness of forming runs have been tried and proposed, practically all of which impair the desirability of the resulting stocking through departing from the preferred plain knit in appearance or fit or in other material ways.

The present invention aims to retain all the established desirable characteristics of the plain knit fabric while solving the problem of preventing runs, by providing an improved stitch which is the equivalent of the basic plain knit stitch in all material respects, and in addition is by the nature of its construction incapable of running.

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According to the invention, in knitting the improved fabric the yarn is not merely doubled into a loop which is pulled through a loop of the preceding course as occurs in the wales of a plain knit fabric, but instead the portion of yarn composing the succeeding loop in the wale passes a full turn around the portion of yarn composing the preceding loop, with the result that no running of the loops or stitches in a given wale above or below the one containing a broken thread, and little or no raveling of the course in which the break occurs, is possible, because of the immediate binding and jamming of the threads adjacent the break.

Other objects of the present invention are to devise a method for knitting the novel fabric and to provide a machine or apparatus whereby this non-run type of knit fabric may be produced, and in particular a fine or sheer knitted fabric of the gages commonly employed for women's stockings and in every way equivalent to the standard plain knit stocking fabric, in addition to having the non-run features, may be made commercially. The manner of attainment of these aims is as shown in the drawings and as set forth in the accompanying description and claims.

In the drawings:

Figs. 1 and 2 are side and front elevations respectively of a knitting machine for producing the novel non-run knitted fabric.

Fig. 3 is a face view on a greatly enlarged scale of a portion of fabric showing the several courses of plain knit fabric followed by one course and part of a second course of the novel non-run stitches.

Fig. 4 shows the starting web set up on the machine needles of the needle bank, the take-up roll, and the bobbin thread made fast to the end of the thread composing the plain knit stitches of the starting web.

Fig. 5 is a plan view of a portion of the needle bank of Fig. 4, showing the hooks on the sinkers engaging and supporting the sinker loops of the terminal course of the starting web.

Fig. 6 shows the manner of making plain knit stitches on the apparatus of Figs. 1 and 2.

Fig. 7 shows the beginning of the formation of the first course of non-run stitches, the starting web being shown as raised into the vertical plane of the needles for clarity.

Fig. 8 is a side view of one sinker and one needle engaged in the formation of the long loop.

Fig. 9 is a perspective view of the needle bank.

Fig. 10 is a side elevation of a sinker, showing its working relation to the front of the needle bank.

Fig. 11 is a perspective view of the quill bank.

Fig. 12 is a front elevation showing the quill bank in one of its positions of adjustment, and the relation of the quills therein to the sinkers and needles.

Fig. 13 is a side elevation of the parts of Fig. 12.

Fig. 14 is a front view of a course of stitches as held by the needles and sinkers, showing the formation of the long loop.

Fig. 15 shows three courses of non-run stitches, with the final course supported by the sinkers and the preceding courses lifted into the same plane as the final course, for clarity of illustration.

Figs. 16 and 17 respectively show the drawing down of the long loop by a needle and the widening of the lower extremity of such long loop as the needle is raised slightly.

Fig. 18 is a front view showing how the widening of the lower extremity of the long loop enables the insertion of a hook to spread the legs of the loop apart.

Fig. 19 is a side view showing the long loop spread by the hook for the passage of the bobbin therethrough.

Fig. 20 is a front view of the long loop with one leg drawn forward by the hook, as in Fig. 19.

Fig. 21 is a front view of the long loop and adjacent loops, showing the bobbin thread forming its first bend around one leg of the long loop.

Fig. 22 shows the position of the bend of the bobbin thread of Fig. 21 within the notch of the sinker.

Fig. 23 is a side elevation showing the normal inactive position of the quill with respect to the sinker.

Fig. 24 is a view similar to Fig. 23 showing the relation of the sinker and quill when the latter is locked in the lower of its two locked positions.

Fig. 25 shows the two locking notches on the shank of each quill, and Fig. 26 shows the locking slide in cooperation with the lower of such notches on the quill shanks.

Figs. 27 and 28 are front and side elevations showing the quill in its depressed position preparatory to passing the bobbin thread around its shank to measure the non-run stitch.

Figs. 29 and 30 show in front and side elevation the passage of the bobbin thread around the quill shank to measure the non-run stitch.

Fig. 31 shows in front elevation the completion of the non-run stitch on one leg of the long loop, with the machine parts omitted.

Fig. 32 is a front view showing the drawing down of the next adjacent needle loop into a long loop.

Figs. 33 to 35 illustrate the sinker loops of the non-run stitches as formed in the slots of the sinkers.

Fig. 36 shows the quill bank adjusted in another of its adjusted positions.

Figs. 37 and 38 show intermediate steps in the removal of the sinker loops of the non-run stitches from the slots in the sinkers to the top surfaces thereof.

Fig. 39 shows a further adjustment of the position of the quill bank.

Fig. 40 shows the means for adjusting and locking the sinkers.

Figs. 41 to 49 show the steps completing the transfer of the sinker loops of the non-run stitches from the slots in the sinkers to the top surfaces thereof.

The machine employed for making the novel fabric in accordance with the new method is shown herein without the inclusion of the mechanical means for actuating the various moving parts, which mechanical or automatic actuating mechanism is of known or any preferred form. For simplicity of illustration and description and clarity of understanding, the moving parts are herein to be understood to be manipulated by hand, as the present description confines itself more immediately to the novel fabric, the method used in making it, and only so much of the thread handling devices and associated parts as are needed to practice the method.

The novel knitting machine comprises a needle bank 1, Figs. 1, 2 and 9, suitably mounted on a base (not shown) by means of supports 3, and a slotted block 5, Figs. 1, 2 and 11, generally similar to the needle bank 1, which I term the quill bank. The front face of the needle bank is slotted as shown in Fig. 9 to provide vertical slots 7 in which work knitting needles 9, Fig. 1, of standard type equipped with pivoted latches 11 as clearly shown in Figs. 46 and 47 and having the usual angularly projecting butts 13. The size and spacing of the needle slots 7 is as desired for the gage of stocking being knitted, there being no limitation imposed by the construction and operation of the present machine on the fineness of gage which is not also met with in standard machines. The top surface of the needle bank is also slotted as shown in Fig. 9 to provide slots 15 for the sinkers 17, Fig. 10, retained therein by a plate 18, Fig. 40, the bottoms of the slots being horizontal and therefore at exact right angles to the bottoms of the vertical needle slots 7. There is a sinker slot 15 midway between each two needle slots 7, and an additional sinker slot 15 beyond each outermost needle slot.

The quill bank 5 is mounted above and in front of needle block 1, being attached by screw 19, Fig. 39, put through an oversized hole in a cross-piece 21 screwed to the forward ends of brackets 23 affixed by screws 25, Fig. 1, to the sides of needle block 1, and also by screws 22 put through a slot in cross-piece 24 and through oversized holes in flanges on brackets 23 into the quill bank. The rear face of quill bank 5 is formed with vertical slots 27, Fig. 11, identical in spaced relation with the needle slots 7, and in these slots are slidably mounted members 29, Fig. 1, which I term quills and which terminate at their lower ends in devices which are substantially identical to the corresponding parts of the latch needles 9 except that, as shown clearly in Figs. 46 and 47, there is a short quill-like extension 31 depending from the point of the hook in spaced and parallel relation to the axis of the shank of the needle, these quills performing a function measuring the length of the stitches and in the transfer of the stitches from the quills to the needles which will be explained later.

In beginning the knitting of the novel fabric, a starting web or cuff of previously-formed plain knit flat fabric of approximately the same gage as that to be made is provided, having near its unbound end a course or row of stitches which are slightly larger in size than the stitches comprising the rest of the web. These larger stitches are placed on the respective quills of a standard straight or flat transfer comb (not shown) of the same gage as the needle bank 1, and the subsequent courses unraveled back to the course thus held, the thread then being cut to leave a short trailing end of two or three inches in length. The quill bank 5 with its quills is removed from the machine by removing screws 19 and 22, the transfer comb held with its quills in register

with the needles 9, and the entire series of stitches of the starting web transferred to the needles, in customary manner. With the stitches thus set up on the machine needles, as shown in Fig. 4, the other end of the starting web 33 is made fast to a take-up reel 35, of any customary or preferred construction, and the desired tension applied to the web by a weight and cord or other suitable torque means (not shown) applied to the reel.

A small bobbin 37, Figs. 4, 6 and 7, is then provided, wound with a supply of the particular thread 38 desired for the fabric to be knitted, and the end of the bobbin thread is tied to the trailing end of the starting web 33. This bobbin and the thread wound thereon constitute the thread supply. To dispose of the trailing end of the starting web and the knot 40, one or more courses of ordinary plain knit stitches are next knitted. It is to be noted that as shown in Fig. 10 each sinker 17 not only has a notch 39 on its working end, but also is provided with a hook 41 directly above such notch, which engages and supports the sinker loops of the terminal course of the starting web which has been transferred to the needles 9, as shown in Fig. 5, the level top surface behind the hook thus acting as a knock-over, and the end of the sinker being of hook-shape to permit one side of a stitch to be pulled away from the face of the needle-bank as shown in Fig. 19 in making the non-run stitch as will be described later, the hook preventing the sinker loop from coming off of the end of the sinker in this process.

In making the courses of plain knit, the thread 38 from the bobbin 37 is laid over the fabric across the width of the needle bank from the hook 41 of each sinker to and through the hook 41 of the next adjacent sinker, but passing in front of the hook 41 of the extreme left-hand sinker, as shown in Fig. 6. For convenience, each of the needles 9 is raised in turn so that the needle loop 45 passes below the latch of the needle, and the thread 38 being laid in front of each needle, above the latch, the bobbin thread 38 is seized by the hook of needle 9, thus forming the plain stitch upon each loop 45 when the needle again descends. This is repeated across the entire set of needles in the needle bank to complete one row of plain knit stitches. Somewhere in this row of stitches the knot 40 made in tying the starting web 33 to the bobbin thread 38 is disposed of, as indicated in Fig. 7, which knot might otherwise prevent the necessary free reeving of the thread in making the long loop 50, Fig. 7, incident to the production of the non-run stitch. A second course of plain knit stitches is knitted from right to left before beginning the non-run fabric, as shown in Fig. 7, to obtain a row of stitches each of which will draw freely when drawn down to become successively the traveling long loop 50 characteristically employed in the non-run construction. At this stage, the quill bank 5 with its quills 29 in the raised position as shown in Fig. 1 is put back on the machine and fixed in place by its retaining screws, in the relation shown in Fig. 12, the quill bank 5 being located slightly off center of the machine toward the left-hand side thereof to bring the extreme left-hand quill 29 directly in front of the extreme left-hand sinker 17, this being effected as shown in Fig. 12 by inserting two spacers 51 between the right-hand end of quill bank 5 and its adjacent bracket 23, screws 19 and 22 being momentarily loosened for this purpose. Each other quill correspondingly

stands directly in front of a sinker 17, except that the extreme right-hand sinker has no quill in front of it, since there is one more sinker than quills. It is also to be noted that quill bank 5 in this first position is set forward in contact with the rear surface of cross-piece 21, as shown in Fig. 13. All quills are in their highest position, as shown in Fig. 1.

In accordance with the invention, the last stitch of this second course of plain knitting, that located at the left-hand side of the fabric as shown in Fig. 7, is then drawn down to an extreme degree, preferably far greater than that employed in forming the plain knit or in standard practice, to form what I term the traveling long loop 50, Figs. 7, 8 and 14. This is effected by picking the butt 13 of outside needle 9 down by hand. Attention is called to the fact that the face of the needle bank 1 is cut back as indicated at 53 in Figs. 9 and 10, so that the hooks of needles 9 project forward from the portion 53 of the face of the needle bank, and thus the long loop 50 suspended from the hooks 41 of sinkers 17 stands clear of the portion 53 of the face of the needle bank, and thus does not make contact therewith.

The object in drawing down the long loop 50 is to produce a stitch loop large enough so that it may be opened up to permit bobbin 37 carrying the supply of thread 38 to be put through this stitch loop of a previous course, as shown in Fig. 7. In stocking fabrics, and in practically all other fabrics as well, the needle loops are too small in their original state to admit of conveniently passing the thread 38 therethrough, much less the bobbin 37. Hence the invention provides the step of momentarily enlarging the previously-formed needle loops of the preceding course in succession across the width of the fabric to enable the bobbin carrying the thread to be put through them successively in knitting a course of non-run stitches, each enlarged loop in turn being drawn back to its original or any desired size after the bobbin has been put through, by the act of enlarging the next successive needle loop for the same purpose.

As the two sides of the long loop actually lie very close together when held down by the pull of the needle 9, and are additionally very close to the face of the needle bank in spite of the cutback 53, it would be tedious to attempt to separate them for the passage of the bobbin by ordinary means. However, I have found that if the needle drawing down the long loop 50 is pushed upward a short distance from its maximum downward position, the thread has by its resilience an inherent tendency to widen the loop at and adjacent the hook of the needle, thus changing its shape from the stressed condition of Fig. 16 to the more open relation shown in Fig. 17 as the downward strain is relieved by upward movement of the needle from the level *a* to the level *b*. Thus the loop 50 becomes wide enough to permit a small hook 55, held in the hand, Fig. 18, to be inserted between the the two sides of the loop and engaged with one side, herein the left-hand side, of the loop so that the portion of thread forming this side may be pulled away from the needle bank, thus shaping the long loop into a large triangle disposed in a plane generally at right angles to the face of the needle bank, through which bobbin 37 carrying the thread 38 is easily passed as shown in Fig. 19. As the loop is thus spread, the needle 9 at the bottom of the loop rises from the elevation shown in Fig. 18 to that of Figs. 19 and 20 as a portion of the other side of the loop

reeves through the needle hook to form a part of the base of the triangle.

As already indicated, the stitch drawn down into the long loop **50** was the last one formed in the previous course with the bobbin thread **38**. With this stitch thus elongated and opened, the bobbin is passed under the left-hand side or leg of loop **50** from left to right, as indicated in Figs. 7 and 19, such loop is again drawn down as shown in Fig. 21 to its original full extent by depressing the needle **9** to its prior position, and the bobbin then returned to the left of the loop **50**. The bobbin thread **38** is thus caused to make a bend or half-turn around the left-hand side of long loop **50**. The necessity for the hook **41** on top of sinker **17** in order to prevent the thread from being pulled off of the sinker as the triangular loop is formed has been made plain in Fig. 19. By lifting slightly upward and pulling on the bobbin thread **38**, the half-turn slides up along the obliquely-inclined end of sinker **17** and settles into the notch **39** formed therein immediately below the hook **41**, as shown in Fig. 22.

Before completing the non-run stitch, it is necessary to measure off and hold a loop in the bobbin thread, in order to determine the length or size of the non-run stitch. For this purpose, the quill bank now comes into use. As shown in Figs. 12 and 13, and as previously noted, the left-hand quill **29** in quill bank **5** is in line with and slightly in front of the left-hand sinker **17**, though all quills are in the raised relation to the sinkers **17** shown in Fig. 23. On the shank of each quill **29** there are two notches **57**, **59**, Figs. 25 and 26. On the top of quill bank **5** is slidably mounted by means of a screw **61** a locating slide **63**, Figs. 1, 2 and 26, having a longitudinal slot **65** to receive screw **61** and a release slot **67** near one end of its rearward edge which edge engages the notches **57**, **59**, in the shank of each quill **29**. At the start, locating slide **63** occupies the lower notches **59** of all the quills **29** to hold them raised in the position of Fig. 23. When the slide is moved to a position where the shank of a given quill is aligned with notch **67**, that quill may be moved in a vertical direction either up or down.

After the bend has been made as described around the left-hand leg of loop **50** and the loop again drawn down, quill locating slide **63** is now moved toward the right until release slot **67** registers with the quill shank of the left-hand quill; this quill being free to move, it is now pushed well down, in front of the bobbin thread **38**, as shown in Figs. 27 and 28. While the quill stands in this position with its hook well below sinker **17**, needle **9** is again raised slightly as in Fig. 17 to partially open long loop **50**, and with the aid of the hook **55** the left side of loop **50** is again pulled away from the face of the needle bank as in Figs. 18 and 19, and bobbin **37** is carried across in front of quill **29** above the hook thereon but below the open latch thereof, and again passed from left to right under the left-hand strand of loop **50** just as was done in making the first bend shown in Fig. 21. The parts then stand as shown in Figs. 29 and 30, with the bobbin thread **38** looped around the shank of quill **29** and with the first bend of the bobbin thread still held in the notch **39** of sinker **17**, as illustrated in Fig. 30. Needle **9** is then moved down to its original full extent, pulling the long loop **50** down into its original position, quill **29** is moved upward to bring its upper notch **57** level with locating slide **63**, and the latter is moved toward the right causing the quill to be locked in the position shown in Fig. 24, with the bend of its hook substantially level with the hook **41** of sinker **17**. The bobbin and its thread **38** are then drawn to the left, thus completing the first non-run stitch, which appears as shown in Fig. 31, disregarding the presence of the needle, quill, and sinkers. As there illustrated this non-run stitch has been formed on the side of needle loop **50**, i. e., on one leg thereof, instead of at the bottom of the loop, as in conventional knitting.

The characteristic feature of the new stitch, which gives it its non-run attribute, is that as shown in Fig. 31 the thread forming this stitch executes a complete turn around the thread of the needle loop of the preceding course with which it is engaged. Made as described, it actually makes 1½ turns. As shown in Figs. 31 and 34, the two legs of the non-run stitch, just completed, respectively pass through the previously formed stitch, the stitch which has been lengthened into the long loop **50**, from opposite surfaces of the fabric, in their extent away from their stitch, the loop of which is now held on the quill **29**. Thus the two bends at the ends of the legs of the non-run stitch, which bends connect this stitch with the lengthened stitch **50**, pass through this latter previously formed stitch **50** from opposite sides of the fabric in their extent away from their stitch. Hence the two legs of the non-run stitch respectively lie at opposite surfaces of the fabric in passing through the previous stitch **50**.

At this stage, the non-run stitch is held on the shank of the quill below the latch **95** thereof, which quill has thus been used to establish the size or length of the novel stitch, while the stitch with which this one is engaged is still drawn down in the long loop **50** and held by the needle as shown in Fig. 29. The long loop having now served its purpose of permitting such prior-formed stitch to be opened in order to knit the non-run stitch thereto, it is next drawn back to its original size by drawing down the adjacent needle **9** to the right of that which has heretofore been employed as described. In so doing, the thread of long loop **50** reeves through the hook of its needle **9**, through the loop immediately above it in the wale, and through the hook of sinker **17** immediately to the right thereof, and the excess length of thread which has up to now formed the first long loop **50** thus passes into the needle loop of the second needle from the left, that which has just been drawn down, to form the second long loop shown in Fig. 32. By this action, the first needle **9** is drawn back by the thread to its original elevated starting position, and as noted its needle loop has returned to its original size, and the surplus length of thread taken out of such stitch is added to the stitch already on the needle in the second needle wale from the left of the fabric by the act of drawing it down. With a new long loop thus provided in such second needle wale, the second non-run stitch is made in the same manner and by following the same succession of steps as in the case of the first non-run stitch described, with the exception that the second needle, quill, and sinker, from the left of the fabric are used. The second quill **29** is locked in the down position of Fig. 24 through engagement of the edge of locating slide **63** within notch **57**, as before, upon completion of the stitch,

there being now two quill shanks 29 to the left of release slot 67 in locating slide 63.

Two non-run stitches have now been completed, and each is held on its respective quill 29; the same steps are now repeated to make successive non-run stitches each engaged with the successive needle loops of the previous course across the entire width of the fabric from left to right, in doing which the length of thread required for opening and widening successive stitches of the previously-formed course is attained by transferring the excess length from the previous long loop to the long loop being formed, thereby shortening the previous long loop to restore the original length of the stitch thus temporarily lengthened and widened to admit the bobbin 37.

With a complete course of non-run stitches thus knitted across the entire width of the fabric from left to right, and with bobbin 37 and its trailing thread 38 now located at the right-hand side of the fabric and machine, the next step before commencing a new course is to knock off the course of plain knit stitches from the needles 9, which is effected by simply pushing the needles 9 upward individually or simultaneously to pass their latches above their needle loops, and then pulling them down again to their original level, thus shedding the stitches.

In this condition, the non-run stitches are each held by the shank of its quill 29, each quill standing in front of a sinker 17, and upon release of the needles from their loops the tension on the web produced by the torque of reel 35 retracts the needle loops of the previous course and thus slides the non-run stitches from the sides of the needle loops of the previous course into the bends or extremities of such needle loops, as shown in Figs. 34 and 35. In this latter figure, and in all corresponding previous figures, it is clearly shown that the portions of the thread forming the sinker loops of the non-run stitches are not on top of the sinker but rest in the slot 39 just under the hook 41 of the sinker. Before knitting a new course, therefore, the sinker loops of the non-run stitches must be moved up onto the top of the sinkers and under the hooks 41 thereof; additionally, the stitches must be transferred from the quills 29 onto the needles 9.

To move the sinker loops of the non-run stitches to the top of the sinkers, the quill bank 5 is shifted toward the right-hand side of the machine one-half of the distance between adjacent sinkers, so as to place the left-hand quill directly in front of the extreme left-hand needle and the rest of the quills in similar relation to the remaining needles. To make this shift, screws 19 and 22 are loosened and one of the spacers 51, Fig. 12, each of which spacers in practice has a thickness equal to one half of the distance between successive needles, is shifted from the right-hand side to the left-hand side of quill bank 5 and inserted between the latter and bracket 23 as indicated in Fig. 36, with appropriate movement of the quill bank to the right, the holding screws being then retightened. Through this movement of quill bank 5 into its second position, shown in Fig. 36, bringing the quills 29 into position in front of the needles with their ends in a plane slightly above the latter, the front ends or needle wales of the loops of non-run stitches around the quill shanks are shifted from in front of the sinkers to positions above and in front of the needles 9. The previously described release of the plain knit stitches from the needles 9 has allowed the tension on the fabric to draw the sinker loops 69 of the previous course of plain knit stitches back from the position shown in Fig. 35 beneath the hooks 41 of the sinkers to the position shown in Fig. 37, where they are well out from under hooks 41. Next, the entire set of sinkers is drawn back toward the rear of the machine, being moved from the position shown in Fig. 37 by the distance *c*, Fig. 38. To govern this movement and maintain the sinkers in either of these positions, a sinker control slide 71, Fig. 40, similar to the quill locating slide 63 is provided, fixed to the back of needle bank 1 by a screw 73 passing through an elongated slot 75 in the slide, the top edge of the slide engaging in one or other of two notches in the under side of each sinker 17, the top edge of the slide being formed with a notch 77 permitting operation of the individual sinkers in the same manner as the quills are operated. Since all the sinkers are to be moved toward the back of the machine at the same time, screw 73 is loosened and two spacers 79 are inserted between the slide and the block each of which spacers is equal in thickness to the dimension *c*, Fig. 38, screw 73 then being re-tightened. This brings all the sinkers in aligned relation into the position shown in Fig. 38.

While the sinkers remain in this second position, each quill 29 in succession across the width of the fabric is raised into the up position of Fig. 23 by manipulating slide 63 into the lower notch 59 in each quill shank. This upward movement of the quills lifts the fabric so that the sinker loops of the course of non-run stitches which are still attached to the quills will be elevated above the sinker hooks 41 as shown in Fig. 41, the rearward shift of the sinkers illustrated in Fig. 38 having freed these sinker loops from their previous position in the notches 39 of the sinkers. Spacers 79 are now removed from behind sinker control slide 71, and screw 73 screwed in to bring the slide back against the surface of needle block 1, with corresponding forward movement of all the sinkers in a body to their original position in Fig. 37. With screw 73 loose enough to permit movement of control slide 71, the sinkers are successively advanced through use of the notch 77 in the slide to enable the slide to occupy the rearward one of the two notches in each sinker, whereby each sinker is advanced from its position of Fig. 37 by a distance *d*, Fig. 42, the space between the two sinker notches. Thereupon all quills 29 are moved into their down position of Fig. 24 by proper manipulation of locating slide 63 to enter the edge of this slide in upper notches 57 of the quill shanks, bringing the entire fabric down onto the sinkers again with the sinker loops, of the course of non-run stitches each upon a sinker just behind hook 41 thereof, as shown in Fig. 43. All the sinkers are then returned to their original position of Fig. 37 by manipulating their control slide 71 to shift the edge of the latter into the forward notch of each sinker.

The result of these manipulations is that the sinker loops of the course of non-run stitches are each engaged beneath the hook 41 of a sinker as shown in Fig. 44.

The next step is to transfer the non-run needle loops from the shanks of quills 29 to the needles 9, which are now empty. It will be noted that a needle control slide 83, Figs. 1, 2 and 45, is provided below the butts 13 of needles 9, this slide sliding horizontally in a frame made up of metal straps 85 and spacers 87 held together and

fastened to the needle bank by screws 89. Throughout the previous operations, a slot 91, wide enough to accommodate two needle butts, in the upper edge of lower slide 63 is brought beneath the successive needle butts as the needles have been successively drawn down in forming the traveling long loop 50. This slide 63 is now removed entirely, and all the needles are pulled down. Quill locating slide 63 is then removed from the machine, and the quills are pushed forward to a position where the loops on the quills are above the latches of the quills as shown in Fig. 46. Thereupon the entire quill bank 5 is moved toward the rear of the machine to bring each each quill into substantially vertical alignment with one of the needles 9, as shown in Fig. 47, to prepare for transfer of the stitches from the quills to the needles. This movement of quill bank 5 is effected by loosening screws 19 and 22, and while spacers 51 are retained in position as in Fig. 36 at each end of the quill bank, a third spacer 93, Fig. 39, is inserted between the front plate 21 and the front of the quill bank 5, screw 19 being then re-tightened.

The needles 9 are then pushed upward, the convex side of the hook of each needle engaging the bend of one of the quills 29 as shown in Fig. 47 and pushing the quill upward through the needle loop of the non-run stitch held by the quill shank, causing such loop to close the latch 95 of the quill and to pass off from the quill entirely, and to be guided by the extension 31 on the quill into the hook of the needle 9. Slide 63 is now reinserted, and all needle butts brought down to the level of the top edge thereof, re-establishing the size of the non-run stitches. The needles 9 are thus back in their starting positions which they occupied when they held needle loops of the plain knit courses, thus completing a course of non-run stitches of the same size as the plain knit portions of the fabric.

To knit the second course of non-run stitches, which will be knitted from right to left, the quills 29, now empty, are restored to their raised starting position of Fig. 23 by restoring the quill locating slide 63 and entering it into the lower notches 59 of the quill shanks, Fig. 25, and also removing the spacer 93 and shifting the spacer 51 from the right-hand side of quill bank 5 to the left-hand side thereof, alongside the other spacer 51 which had been placed there as described. When knitting from left to right as related, the non-run stitch was made by passing the bobbin 37 repeatedly around the left-hand leg or side of the traveling long loop, with the quill bank at its extreme left-hand position shown in Fig. 12 to bring the quill at the extreme of the bank in register with the sinker 17 at the extreme left of the machine, thus causing each quill loop to be formed around the quill standing at the left of the needles which eventually receive this loop. Now in knitting from right to left the right-hand side or leg of the traveling loop is encircled by the bobbin thread in making the non-run stitch, as shown in Fig. 48, and hence the quill must be located at the right-hand side of its corresponding needle. Thus the quill bank 5 is shifted to its extreme right-hand position, against the right-hand bracket 23, for this purpose, each spacer 51 having a thickness equal to one-half the distance between adjacent needles and thus the two together moving the quill bank to the right the full distance between two adjacent needles.

In knitting from right to left, the steps outlined hereinbefore as to forming the successive non-run stitches are repeated across the entire width of the fabric, forming the novel stitch on the right-hand leg of each needle loop of the preceding course of non-run stitches as indicated in Fig. 48. The fact that the preceding course of stitches whose loops are now successively opened to admit the bobbin is now of non-run construction does not in any way impede the drawing down of the long loop, or the retraction of such loops into their final intended size, the excess length of thread needed to form the long loop being provided and recovered through reeving of the thread through the hook of the needle, the preceding needle loop, and the hook of the sinker, just as before.

With the course of non-run stitches completed from right to left and held on the quills, one of the spacers 51 is shifted to the right-hand end of quill bank 5 to bring the quill bank into the position shown in Fig. 36, with each quill in front of its respective needle. Thereafter, the stitches are knocked off, the sinkers and quills are manipulated, and the same manner and order of procedure is followed as was done with the course of non-run stitches knitted from left to right.

To simplify the understanding of the basic method, the question of disposing of the excess length of thread drawn from the bobbin to form the traveling long loop and worked backward through the successive stages of the preceding course to the end thereof which was knitted first, and no longer needed now that the succeeding course of non-run stitches has been completed, has been omitted in the description thus far. Various ways of disposing of the long loops thus left at the starting end of the final course of plain knit stitches, and, as will appear, also at the starting end of each course of non-run stitches, are available; in some cases, the long loops are each drawn out laterally beyond the first stitch in each course, restoring such stitch to its original size, and then each loop is laid back over the knockover surfaces of the sinkers in front of the slightly raised needles of a succeeding course for as far as it will reach inward from the selvage, the needles then being depressed to knit the doubled length of thread in the loop into the first 3 or 4 stitches of such course. When this is done, the 3 or 4 stitches involved are always made of plain knit throughout the fabric length, to dispense with the hooks 41 on the sinkers so as to facilitate laying the loop of thread on the knockover surface in position to be seized by the needles.

However, a preferred way of disposing of the excess length of thread contained in the long loop left over in each course after it has served its usefulness, comprises the step of borrowing the length of thread needed for the formation of the long loop from the course in which the long loop is working, by creating an intentional deficiency of length in the beginning of the same course in which this excess length is eventually to be disposed of, through forming a certain number of stitches in each course of subnormal length, and thereafter working back into them the otherwise excess length of thread left over in the long loop after it has served its purpose, thus absorbing such long loop completely in subsequently drawing down these short-length stitches into the same length of stitch prevailing throughout the rest of this course and generally throughout the fabric.

It is to be understood that the size of the travel-

ing long loop, and hence the excess length of thread thus left in the preceding course, is determined by the size of the bobbin 37 which is to be put through the long loop 50. Assuming for purposes of illustration that each stitch, plain or non-run, needs to be enlarged to five times its final desired size in order to make the long loop large enough to put the particular bobbin 37 through it conveniently, in making the non-run stitch, it will be seen that if the first four stitches of a completed course are drawn flat and allowed to have no length at all, as shown in Fig. 49, the surplus four stitch lengths taken from the bobbin, and introduced first into the final stitch of such course to form the traveling long loop and thereafter worked backwards successively through the stitches of such course, can be absorbed in these first four flat stitches by the step of subsequently enlarging them by drawing them down to give them the same length as that intended to prevail throughout the fabric.

For example, assuming that a row of plain knit stitches has been knitted from left to right, and the final row of plain knit stitches is about to be knitted from right to left: the first four plain knit stitches are knitted from right to left, and thereupon these four needles are moved up until their needle loops are freed from all downward pull and the hooks of the needles are well above the level of the knock-over surfaces of the sinkers, as shown in Fig. 49. The bobbin thread 38 is then drawn taut to flatten out these four needle loops, drawing them tight against the needles between the hooks and the latches thereof, as shown in Fig. 49. Leaving these four needles in this raised position, the formation of ordinary plain knit stitches of the same length as in the preceding course is carried out across the remaining width of the fabric clear to the left-hand side of the machine. Thereafter, and as described at length hereinbefore, the extreme left-hand needle is drawn downward to form the first traveling long loop previously referred to, such needle being depressed to a distance where the length of thread entering into its loop equals the length initially given to and subsequently restored to this stitch, plus the material robbed from the four right-hand needle loops in pulling them flat as just described, or a total of what may be called five stitch-lengths. This length of the traveling long loop formed on the first needle from the left to start the first course of non-run stitches, and as stated needed to get the particular size of bobbin used through this long loop, is measured off by bringing the needle butt 13 to the bottom of notch 91 in laterally movable slide 83, the bottom of the slot thus acting as a gage to measure off and determine the length of the long loop, as before. Upon this first long loop is knitted the first non-run stitch as shown in Figs. 7, 19, 27, and 29 to 31 and as previously described. In this manner the first four non-run stitches of this course are knitted, and will be on the quills 29 as shown in Figs. 34 and 35. Thereupon, with the traveling long loop on the 5th needle from the left, and before proceeding with the formation of more non-run stitches, these four non-run stitches are transferred from the quills 29 to their respective needles 9, after the manner set forth hereinbefore, with the necessary manipulation of quill bank 5, which is thereafter restored to its working position of Fig. 12. At this stage then, the first four left-hand needles hold the first four non-run stitches of the first non-run course, the next needle to the right beyond this group is in depressed position in slot 91 of slide 83 and holding the travelling long loop pendent from the preceding course of plain knit stitches, the needles immediately to the right of such depressed needle hold the needle loops of the normal-size plain knit stitches of such preceding course, while the four needles at the extreme right are in raised relation as shown in Fig. 49 extending through the four flattened stitches at the starting end of the previous plain knit course.

The four non-run stitches thus formed and now held on the four left-hand needles are next flattened out in the same manner as was done with the four stitches at the right-hand end of the preceding plain knit course, Fig. 49, and for the same purpose of preparing for the absorption of the length of thread used to form a traveling long loop in this non-run course in the process of adding a succeeding reversely-knitted non-run course thereto. Thus, as before, these four left-hand needles are moved upward until their needle loops stand below their hooks, and the bobbin thread is drawn to the right until the loops are pulled flat against the raised needles and extends in a substantially straight line across the knock-over surfaces of the associated sinkers. As noted, stitches from two successive courses stand on the needles, but the four stitches at each side of the fabric have been drawn flat, the four left-hand stitches being of non-run character, while the remaining stitches are of plain knit form. Thereupon the knitting of the first course of non-run stitches is continued from left to right through the use of the traveling long loop, after the manner described, but as the traveling long loop is drawn down by the 4th needle from the right, the fifth needle from the right is raised to the level of the adjacent four raised needles so that its plain knit loop can in turn be flattened by reeving the material therefrom into the long loop of the 4th needle from the right, to enable the long loop formed with this 4th needle from the right to attain its full size in spite of the deficiency of one stitch-length resulting from its having been flattened. That is, the release of the needle loop of the 5th needle from the right in this manner enables the length of this stitch to be temporarily added to the long loop on the 4th needle from the right, to give it the requisite five stitch-lengths attained heretofore in knitting this non-run course. After making the non-run stitch on this long loop held by the 4th needle from the right, and in transferring the material of the long loop to the third needle from the right by drawing down the latter, the 4th needle is similarly raised above the knock-over surface and its plain knit needle loop flattened again, to give the long loop on the third needle from the right the necessary length. By the same procedure, the non-run stitches are formed on the plain knit needle loops held by the second and first needles from the right, resulting in the completion of the first course of non-run stitches, at which stage the long loop is held down by the first needle from the right.

This long loop has now fulfilled its usefulness in this course. As predetermined, the long loop contains just the length of thread needed to restore the flattened 2nd, 3rd, 4th and 5th plain knit stitches from the right-hand side of the fabric to their original size, with just enough left over to make the needle loop on the first needle from the right of the same size as it was initially. So the next step is to distribute the length of thread, left over after drawing the first needle

loop from the right back to its original size, equally amongst the flattened 2nd, 3rd, 4th and 5th stitches from the right. To do this, the 2nd needle from the right is drawn downward, causing the thread to reeve from the traveling long loop, thus drawing the first needle from the right upward to a point where the lower edge of its butt is level with the upper edge of slide 83, which leaves just enough material in the first needle loop to restore this stitch to its original size. The traveling loop held by the second needle from the right contains enough material to complete the 2nd, 3rd, 4th and 5th stitches from the right. In like manner, the 3rd needle from the right is moved downward to cause the 2nd needle to be drawn upward until the lower edge of its butt reaches the level of the top edge of slide 83, where it remains, as does the first needle. The same procedure is followed with the 4th needle from the right, causing the 3rd needle to rise to this same level, at which stage the 4th needle holds down a loop containing twice the initial stitch length. Upon moving the 5th needle from the right downward until its butt's lower edge contacts the upper edge of slide 83, the 4th needle rises to where its butt's lower edge is level with the upper edge of slide 83.

By these steps, the length of thread left over in the traveling long loop after it has served its purpose is absorbed and distributed in the plain knit course through which it was worked backward, thus leaving a course of stitches all of uniform size.

This done, all the needles except the four at the left-hand side holding the flattened four non-run stitches are raised until their needle loops pass below their latches, and then depressed to cast off the entire remainder of the course of plain knit stitches which up to now has occupied all of the needles except the four at the extreme left, previously cast off. Following this, the non-run stitches now held on the quills, which includes all except the four at the extreme left, are transferred to their respective needles, by the manipulation previously described herein and involving the shift of the quill bank 5 to bring its quills 29 into alignment with the respective needles 9 as shown in Fig. 36, and the casting of these stitches from the quills onto the needles by the operation indicated in Fig. 47.

The second course of non-run stitches is thereupon knitted from right to left in similar manner, the bobbin being at the right-hand edge of the fabric at the completion of the first course of non-run stitches. As before, sufficient material is drawn from the bobbin to provide the traveling long loop, which is worked back through the preceding non-run course from right to left to permit successive enlargement of these stitches to let the bobbin through, followed by restoration of these stitches to their initial size, which is also their final size, with eventual absorption of the material of the traveling long loop at the left-hand end of the preceding non-run course in restoring to their final size the four non-run stitches at the left which had previously been flattened in preparation to receive and retain this otherwise surplus length of thread after the long loop has served its purpose, all as just described, including the transfer and flattening of the first four stitches of this course immediately upon their completion, to absorb the long loop of the third course.

The knitting of the successive courses of non-run stitches is continued in identical manner until the desired length of fabric is completed, the courses alternating in direction successively from left to right and from right to left as usual, the first four stitches knitted in every course being as stated transferred from their quills and flattened as soon as made and before continuing the course, to absorb the traveling long loop, which is initially created in each course by enlarging the last made stitch thereof, and traveling backward through such course to its beginning end, and eventually being absorbed in that same course through the flattening of the first four stitches and the robbing of the 5th stitch therein followed by restoration of the initial size of all five of these stitches. The stitch at the beginning end of each row is restored first; the 2nd stitch from this end is restored next, and the 3rd, 4th and 5th stitches from this end are successively restored in that order.

Conventional methods of widening and narrowing the fabric are employed as desired, as in shaping a stocking fabric, the invention process and apparatus presenting no special difficulty in this respect.

An enlarged specimen of the novel knitted fabric made in the manner and with the apparatus just described is shown in Fig. 3, in which the upper two complete courses illustrate the plain knit or regular stitch and the lower two courses, respectively complete and partial, illustrate the novel non-run stitch and its manner of interengagement both with the plain knit course and with a succeeding non-run course. This figure also shows the construction of the selvages resulting from the described novel method.

It is to be understood that courses of plain or fancy knit may be interposed between rows of non-run stitches in any combination or sequence that may be desired.

While I have illustrated and described a certain form in which the invention may be embodied, I am aware that many modifications may be made therein by any person skilled in the art, without departing from the scope of the invention as expressed in the claims. Therefore, I do not wish to be limited to the particular form shown, or to the details of construction thereof, but

What I do claim is:

1. The method of knitting which includes the steps of enlarging a previously formed stitch and thereafter passing the thread supply twice therethrough in the same direction and thus around the thread of such previously formed stitch in forming the corresponding stitch of a succeeding course.

2. The method of knitting which includes the steps of enlarging a previously formed stitch and passing the thread supply twice in the same direction therethrough in forming the corresponding stitch of each succeeding course and thereafter reducing the size of the thus enlarged stitch.

3. The method of knitting which includes the steps of knitting a course of stitches, enlarging at least some of such stitches, passing the thread supply twice in the same direction through each of the enlarged stitches in forming the corresponding stitches of each succeeding course, and thereafter reducing them to substantially their original size, one at a time.

4. The method of knitting which includes the steps of knitting a course of stitches, temporarily enlarging at least some of such stitches, passing the thread supply twice in the same direction

through each of the enlarged stitches in forming the corresponding stitches of each succeeding course, reducing them to substantially their original size, one at a time, and incorporating the length of thread involved in the temporary enlargement of these stitches into the stitches of a course of the fabric.

5. The method of knitting which includes the steps of knitting a course of stitches, successively enlarging some at least of such stitches, passing the thread supply twice in the same direction through each enlarged stitch to form a stitch of the next succeeding course, and thereafter reducing each enlarged stitch to smaller size by enlarging an adjacent stitch.

6. The method of knitting which includes the steps of enlarging a previously formed stitch, passing the thread supply therethrough, holding a loop in the extent of thread between the stitch and the rest of the thread supply, and passing the thread supply again through the stitch in the same direction as before.

7. The method of knitting which includes the steps of forming a course of stitches, forming a second course of stitches engaged with the first course while the latter is held by a series of needles, releasing the first course from the needles, and transferring the second course thereto.

8. The method of knitting which includes the steps of enlarging a previously formed stitch, passing the thread supply therethrough, holding a loop in the extent of thread between the stitch and the thread supply, and passing the thread supply again through the stitch in the same direction as before and thereafter transferring this stitch to a needle.

9. The method of knitting which includes the steps of knitting a course of stitches, enlarging such stitches in succession in the reverse order to that in which they were formed, passing the thread supply through each stitch while enlarged in forming the corresponding stitches of each succeeding course, distributing the length of thread involved in the enlargement of the stitches among the stitches of this course, and reducing each stitch to its original size.

10. The method of knitting which includes the steps of knitting a course of stitches, making certain of such stitches of deficient length, enlarging the stitches, passing the thread supply through the enlarged stitches to create a new course of stitches, and thereafter giving all the stitches a substantially uniform length.

11. The method of knitting which includes the steps of knitting a course of stitches, drawing from the thread supply a sufficient length of thread to permit momentary enlargement of one stitch thereof for the passage of the thread supply therethrough, working this length through other stitches of this course to permit successive momentary enlargement of such stitches and the passage of the thread supply therethrough, and absorbing this length in such course by enlarging to the same size as the rest of the stitches a number of stitches previously made deficient in length.

12. In a knitting machine, in combination, needles, members providing knockover surfaces, and spreader means enlarging a previously formed needle loop while the latter continues to be held by a needle and the knockover surfaces.

13. In a knitting machine, in combination, members providing knockover surfaces, needles forming loops in the thread, and means holding aside a bend in the thread after the latter has been put through a needle loop held by a needle and the knock-over surfaces.

14. In a knitting machine, in combination, needles forming loops in the thread, means enlarging a needle loop to permit the passage of the thread supply through such loop twice in the same direction, and means holding aside a bend in the thread, such bend being formed in the portion of the length of the thread lying between its first and its second passage through the needle loop.

15. In a knitting machine, in combination, needles forming loops in the thread, means enlarging a needle loop to permit carrying the thread supply a full turn around the thread comprising such previously formed needle loop, and means holding an intermediate portion of such full turn away from the thread of the needle loop.

16. In a knitting machine, in combination, needles forming loops in the thread, means enlarging a needle loop to permit carrying the thread supply a full turn around the thread comprising a previously formed needle loop, and means holding an intermediate portion of such full turn away from the thread of the needle loop and subsequently transferring such portion to a needle.

17. In a knitting machine, in combination, a needle mounted for vertical and lateral movement, means supporting a length of thread adjacent the needle while the latter draws a lateral loop therein, through which loop another length of thread is to be carried while the latter is held by the needle, and means holding aside a bend in the second length of thread to form a stitch engaged with the needle loop.

18. The method of knitting which includes the steps of knitting a course of stitches a number of which are made of deficient length, drawing from the thread supply a sufficient length of thread to permit momentary enlargement of one stitch thereof for the passage of the thread supply therethrough, passing the thread supply twice in the same direction through such stitch, working this length through other stitches of this course to permit successive momentary enlargement of such stitches and the passage of the thread supply twice in the same direction through each, and absorbing this length in such course by enlarging to the same size as the rest of the stitches the number of stitches previously made deficient in length.

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